Reading the Book of Nature

An Introduction to the Philosophy of Science

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INTRODUCTION

SCIENCE enjoys a lot of respect these days, if not always for the social value of its results then at least for the rigor and precision of its methods. It is an honor to say of a study or an argument that it has been done scientifically. This must be because we think that, in general, science and scientific methods are effective for getting at the truth. If pressed to articulate these feelings we might start by saying that the careful, accountable, and methodical approach of science prevents, as much as possible, the influence of personal bias, superstition, sloppiness, whimsy, sloth, and other human weaknesses that obscure the truth. Thus, when we claim to have done something scientifically, we speak with the authority of a truth-generating enterprise.

There has to be more to it than just being careful (careful to do *what?*) and accountable (accountable by what standards?), and we can appropriately ask why science has its special status as a supplier of knowledge about the world. Thus the unifying question in the pages that follow is, Why should we believe what science says about the world?

This is a question of justification of scientific knowledge. It asks not so much about *what* science claims about the world but more about *how* science proves what it does claim and why it gives us reason to believe that these claims are true. To ask about the justification for knowledge is not an attack on its credibility. There is no implication of skepticism here, and the request for proof is not a veiled suggestion that there is none to give. Instead, the concern for justification represents a requirement of responsibility that is the burden of any purveyor of knowledge. Not just any belief or

statement counts as knowledge, only those that can be justified as likely to be true.

Perhaps, in the case of science, finding the justification is as easy as giving credit for success. Science gains credibility from its phenomenal success. Airplanes fly. Smallpox has been done away with. Humble uranium gets turned into electricity, which in turn keeps the Bud Light cold. This record of success may be enough to give us responsible warrant to believe that science, by and large, gets at the truth about the world, but there are three reasons why this appeal to success is just a suggestive beginning to the analysis of scientific justification.

For one thing, the most interesting science – that is, the sorts of claims whose justification we are most interested in – is about things that nonspecialists can never check for themselves. The currency of science is largely of unobservable entities such as electrons, black holes, DNA molecules, tectonic plates, and the like. We can *see* that airplanes fly, but how do we know that the electrons in an accelerator or in an atom do what the physicists say they do? What counts as success of a theory that is about things that can never be experienced? The criteria and measure of success in this domain are the business of experts, the scientists themselves, and in this sense science is a largely self-regulating business whose success in crucial areas is self-proclaimed.

Again, this is not intended as a threat to the integrity or credibility of science. It is, though, a warrant to investigate further just what it is about science and doing things scientifically that justifies belief in the results being true.

A second reason to be skeptical of the direct association of success as justification is the undeniable fact that the scientific description of the world changes over time. It was once respectable and successful science to describe the universe as being full of ether, and for a very long time the scientific account of the heavens placed the planets and stars in crystalline spheres centered at

and revolving around the earth. We no longer take these once-successful theories to be true. Such a dramatic turnaround should be sufficiently humbling to allow us to ask whether quarks and quasars aren't just today's flash in the pan, which may appear as object lessons in the introduction to a book written years from now on justifying scientific knowledge. An arrogance of the present (yes, but *now* we've got it right) can be avoided by focusing on a general method by which to tell when we've got it right.

The third motivation for looking beyond success is this: Even if these worries about the evaluation of success (it's left up to internal review; it's too ephemeral) could be put aside, there is a deeper question of interest here. What fuels the success? To say that something is done scientifically is not to say simply that it is done with success. Success may be the result, but it is not the methodological structure. What then is this structure, and what about it gives us reason to think it produces truths?

Putting the question in this way motivates the plan of presentation in the following chapters. The first step in the analysis will be an accurate description of the scientific enterprise, focused on the activity of justification of theories rather than their discovery. A clear account of the process of science will then be the evidence for deciding the issue of justification. Once the picture is clear as to how science works, the next step is to ask whether this way of working is conducive to producing the truth. The motivating goal is to be able to evaluate the justification of scientific claims, but first we need to know just what it is we are evaluating.

The specimen under observation here is going to be science at its best. We will not be concerned with fraud in science, episodes such as lying about experimental results, fudging the numbers, and other willful violations of the code of good scientific practice. The topic is the code itself and an assessment of its truth-conduciveness when properly followed. This abstract level of analysis is analogous to a political scientist's study of a social

policy to see if it facilitates a just distribution of social welfare. Of course, there will be cheaters, but before dealing with these problems, the analyst wants to know the worth of the policy when it is properly enforced. Can it deliver as it promises, whether it promises justice or truth, when it is working at its best?

All this talk of justification of scientific knowledge and the scientific method makes it sound as if we have license to generalize about all sciences following a single method at all times. But surely the methods differ from scientific discipline to discipline. From astronomy to zoology, the diverse varieties of sciences study very different kinds of objects and very likely require different ways of theorizing and testing. Even within each domain it is unlikely that there is a single road to the truth, appropriate for all circumstances.

Just as surely, though, all these endeavors have *some* aspect of method in common, and it is this shared methodological ground that is the object of study here. What is it that allows all of these disciplines to be described as being done scientifically and as presenting characteristically scientific evidence? It is at this level of generality that we operate here, and I intend to demonstrate that the common methodological factor in the sciences (when done at their best, don't forget) is important as a truth-indicative ingredient. In other words, working at the high level of generality does not force the discussion to rise above all that is interesting and into the realm of only trivial generalizations. Granted that many of the features common to all the sciences are unimportant to evaluation of justification, there are nonetheless some common features that are significant to justification. But there is no need for you to believe this now, because the demonstration of this point is exactly the burden of what is to follow.

To be blunt, then, I do plan to generalize across the sciences and to proceed as if there is, at some level, a unity of method. I plan to generalize this much and then some by suggesting that the methodological mark of good science is what we take to be

the character as well of good common sense. In other words, as in science so too in life on the street. A close look at science is as a view of our less glamorous reasoning processes under a microscope, in that science is a slowed-down, more open and accountable image of what we normally do in coming to know about the world around us. Good science is an image of good sense.

I do intend to pay attention to a distinction between natural and social sciences, and the discussion here will be limited (though not strictly) to the natural side of the divide. The book of nature is of things without minds or the ideas, intentions, and emotions that are characteristic of minds. The focus on the natural world is not meant to suggest, though, that studying different kinds of objects, nonmental versus mental, necessitates wholly different methods of theorizing and justification. In fact, there is good reason to believe that the methodological model of the natural sciences also fits rather neatly onto the social sciences. I hope to motivate this belief by applying the understanding of natural science to examples of archaeology, indicating that this bridge discipline, with clear affinities to both natural and social studies, is methodologically similar to the natural sciences.

Furthermore, the model that will be used throughout for understanding natural science is one that is most often used in describing social sciences. This is the model of reading a text. Just as science builds models of the world, describing gases as crowds of colliding point-particles, for example, this study of science builds a model of the process of science as being methodologically like reading and interpreting a book, the book of nature. The method by which science comes to understand the natural world is very similar to the method used to understand the meaning of a text written in an unfamiliar language. Understanding the mechanism of nature is like understanding the plot. It is important to realize that this analogy between science and reading is intended to apply only at a methodological level. Though the methods of understanding and justification may be similar between the two

activities, this does not imply that their subject matter is similar as well. In particular, the methodological analogy is not meant to suggest that nature has an author.

The translator of an unfamiliar text comes to understand its meaning through an attention to context. Recurring patterns in the symbols on the page prompt speculation about the meanings of passages, and most importantly, these speculations are testable and amenable to revision. Under the assumption that the text makes sense, that is, that the passages are consistent and they cohere, at least in small sections, into a cogent message, testing a speculated translation of a symbol is done by applying it to other occurrences in other contexts to see if it still makes sense. If the passage comes out as nonsense, the hypothesis must be revised. Through this back-and-forth of suggestion and revision, an understanding of the plot develops and is used to facilitate finding the meaning of passages by giving them a large context into which they fit. Thus the understanding of the whole text guides the interpretation of the parts, and the whole message is itself composed of the meaning of the parts.

This is what happens in reading the book of nature. Instead of marks on a page there are the experiments and observations done by scientists, but like the unfamiliar marks on a page, the observations are meaningless without some prior understanding, if only at the stage of revisable speculation, of what's going on in the story. In the context of science, the observations aren't evidence of anything without a theoretical description of their relevance. For example, the data of a particle detector are interesting only if we know already that a click means that an electron has passed through. Theories, such as the one that describes the link between clicking meters and passing electrons, represent an understanding of general aspects of how the world works and will influence the interpretation of individual pieces of observational evidence. Thus the big picture guides the interpretation of the parts. And of course the theoretical understanding of the big

picture is built from and tested against the individual, observational parts.

This reasoning may sound circular, both in the case of translating a text and in that of acquiring knowledge of the natural world, but it is not necessarily a harmful circularity. In both situations, translating and knowing about the world, the project is to describe what is going on behind the scenes. The achievement of science or of translation is to make expansive inferences about things other than but significantly related to what is apparent. It's not interesting simply to describe the appearances, to reproduce or analyze the marks on the page. We want to know the story. We want to know what the marks mean. In science we will never get a look at the answer key, in the form of an authoritative translation of the book or even a dictionary, so we must learn to do the best we can with the available information. The developing theories and theoretically influenced evidence are all we have to go on to draw an accurate description of the world. Of course, somehow this cozy relationship must be regulated to insure a factual reading of the book of nature. What then constrains this process in the direction of truth? That is exactly the right question to ask, and it is time to get on with answering it.

A bit of advice to the reader: The form of this book is true to the message of its content. Individual chapters will make sense and attain their full meaning within the context of the whole work. This is just a friendly warning that the contents are not piecemeal, and parts taken in isolation will convey less information than those parts taken as they participate in the whole. But reading this book will be easier than reading the book of nature, at least in that this one has a lexicon, a glossary of key terms at the end. Terms that are included in this glossary, when first mentioned in the text, will be printed in bold type.